DOCUMENT RESUME

ED 293 719 SE 049 103

AUTHOR	Somers, Lee H.
TITLE	Oceanography for Divers: Hazardous Marine Life. Diver Education Series.
INSTITUTION	Michigan Univ., Ann Arbor. Michigan Sea Grant Coll. Program.
SPONS AGENCY	National Oceanic and Atmospheric Administration (DOC), Rockville, Md. National Sea Grant Program.
REPORT NO	MICHU-SG-86-510
PUB DATE	88
GRANT	NA85AA-D-SG045
NOTE	40p.; For related documents, see SE 049 104-105.
AVAILABLE FROM	Michigan Sea Grant Publications, 2200 Bonisteel Blvd., Ann Arbor, MI 48109-2099 ($2.00).
PUB TYPE	Guides - Classroom Use - Materials (For Learner) (051)
EDRS PRICE	MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS	*Animals; *Aquatic Sports; *College Science; Earth Science; Higher Education; Marine Education; *Oceanography; Pollution; *Recreational Activities; Science Education; Swimming; *Underwater Diving; Zoology
IDENTIFIERS	*Informal Education

ABSTRACT

Most people find that the life of the marine environment is beautiful and fascinating. Of the thousands of marine animals and plants, relatively few constitute a real hazard to the diver. Although some species are dangerous and may, in some instances, inflict serious wounds, with a few exceptions marine animals are not aggressive. Most knowledgeable divers feel that it is through the diver's own carelessness that injury results. It is advisable that they be able to recognize animals that are capable of inflicting damage, know how to avoid injury, and be able to administer proper first aid in event of injury inflicted by marine organisms. This discussion characterizes the major groups of marine animals that are known hazards to divers. No attempt has been made to discuss individual species in detail. Geographically, the discussion concentrates on the tropical waters of Florida, the Caribbean, and the Bahamas; however, reference has also been made to animals of the western coast of the United States and the South Seas (including Australia's Great Barrier Reef). Also included are discussions of marine and freshwater plants and diving in polluted waters. (CW)

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DIVER EDUCATION SERIES

Oceanography for Divers: Hazardous Marine Life

Lee H. Somers

Michigan Sea Grant College Program

MICHU-SG-86-510

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This publication is the result of work sponsored by the Michigan Sea Grant College Program with grant NA85AA-D-SG045 from the National Sea Grant College Program, National Oceanic and Atmospheric Administration (NOAA), U.S. Department of Commerce, and funds from the State of Michigan.

Ordering information for additional copies of this publication can be obtained from: Michigan Sea Grant Publications, 2200 Bonisteel Boulevard, The University of Michigan, Ann Arbor, Michigan 48109; 313/764-1138.

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DIVER EDUCATION SERIES

OCEANOGRAPHY FOR DIVERS: HAZARDOUS MARINE LIFE

Lee H. Somers, PhD

INTRODUCTION

The life of the marine environment is beautiful and fascinating. Of the thousands of marine animals and plants, relatively few constitute a real hazard to the diver. Although some species are dangerous and may, in some instances, inflict serious wounds, with a few exceptions marine animals are not aggressive. Generally, it is through the diver's own carelessness that injury results. The diver should respect, not fear, marine animals. He must be able to recognize animals that are capable of inflicting damage, know how to avoid injury, and be able to administer proper first aid in event of injury inflicted by marine organisms. **In addition to specialized training in diving related accident management/first aid, all divers are encouraged to acquire training in standard American Red Cross first aid practices or the equivalent.**

This discussion will characterize the major groups of marine animals that are known hazards to the diver. No attempt will be made to discuss individual species in detail. Geographically, the discussion will concentrate on the tropical waters of Florida, the Caribbean, and the Bahamas; however, reference will also be made to animals of the western coast of the United States and the South Seas (including Australia's Great Barrier Reef). **Divers are encouraged to consult with local authorities regarding marine hazards whenever they travel to unfamiliar diving areas.**

This publication has been developed as a support document for Michigan Sea Grant College Program lectures which include a visual presentation of all organisms discussed. To reduce printing cost, illustrations of the organisms have not been included in this publication. Readers are encouraged to consult any of a number of popular publications such as National Geographic Magazine, Cousteau publications, nature guides, and the many excellent pictorial publications by various noted photographers [4,5,8,21,25,26].

For convenience, the marine animals will be divided into the following categories:

1. marine animals that sting
2. marine animals that abrade, lacerate, or puncture
3. marine animals that bite
4. marine animals that have venomous bites
5. miscellaneous hazardous marine animals

MARINE ANIMALS THAT STING

Most marine animals that inflict injury by stinging their victim belong to the phylum Coelenterata. This phylum includes about 10,000 species in three major classes: Hydrozoa (hydroids, fire coral, and Portuguese man-of-war), Scyphozoa (jellyfish), and Anthozoa (sea anemones and corals). Although all coelenterates have stinging tentacles, only about 70 species have been involved in human injuries. However, over 90% of the venomous wounds and stings suffered by divers are from members of this phylum.

Coelenterates are characterized by their unique stinging cells, or nematocysts, which are situated in the outer layer of tentacle tissue. This apparatus consists of a trigger hair which, when touched, actuates a spine, followed by a hollow thread through which a paralyzing drug is injected into the victim. When a diver brushes against or becomes entangled in the tentacles of some coelenterates, thousands of tiny nematocysts may release their stinging mechanisms and inject venom.

Symptoms produced by the stings will vary according to the species, locality, extent and duration of contact, and individual reaction variations. Chemical toxins promote an allergic reaction in the skin. Some individuals are more sensitive than others to stings and will exhibit more severe reactions. The more nematocysts that strike the victim, the greater the impact. Thus, it stands to reason that larger specimens can be more dangerous than smaller ones. Conceivably, a sensitive individual in contact with a large Cyanea could suffer physiological shock and then drown. On the other hand, an encounter with Cyanea as well as many other jellyfish species may result in little or no discomfort for some individuals. Symptoms may range from a mild prickly or stinging sensation to a throbbing pain which may render the victim unconscious. The pain may be localized or radiate to the armpit, groin, or abdomen. Local redness may be followed by inflammatory swelling, blistering, or minute skin hemorrhage. Following contact with some large species, certain individuals may experience shock, muscular cramps, loss of sensation, nausea, vomiting, severe backache, frothing at the mouth, constriction of the throat, loss of speech, breathing difficulty, paralysis, delirium, convulsion, and possibly death.

Stinging Coral

Stinging coral or **fire coral** is actually not a coral, but a member of the class Hydrozoa. Members of the genus Millepora are found among the true corals in warm waters throughout the tropical Indo-Pacific and Atlantic Oceans, Red Sea, and Caribbean. Common Florida and Bahamas species are Millepora complanta or Millepora alcicornis which have a characteristic tan-colored, bladed-type growth with lighter (almost white) upper portions. Millepora may appear in a bladed growth form or an incrusting form over rock surfaces or on the branches of soft corals such as alcyonarians. The Millepora zone of the outer Florida Keys reefs ranges from 10 to 25 feet deep. Contacts with Millepora are relatively common, with symptoms generally limited to a stinging sensation and reddening of the skin.

Portuguese Man-of-War

The **Portuguese man-of-war** (Physalia physalis) is often mistaken for a jellyfish. This hydroid, also called blue bottle, floats on the water's surface in all tropical oceans and the Mediterranean Sea. It appears as a blue transparent jelly-like mass with tentacles bearing large numbers of nematocysts trailing several feet down into the water. A single tentacle may have as many as 75,000 nematocysts. The Portuguese man-of-war drifts with the currents and may be found in localized large concentrations. This hydroid, producing a cobra-like toxin, has been responsible for many injuries in Florida and Bahama waters, with symptoms ranging from minor irritation to shock and respiratory arrest. Other species that produce similar injuries include the Velella velella (purple sail) and Porpita umbella.

Jellyfish

The class Scyphozoa includes the large, bell-shaped medusae, having eight notches on the margin, and many other species that constitute potential danger for the diver. The **sea wasp**, represented by several species, including Chiropsalmus quadregatus and Cheronex fleckeri, is one of the most lethal venomous marine animals known to man. It is an especially dangerous inhabitant of Australian and Philippine areas and the Indian Ocean. Stings of the sea wasp have been responsible for a number of human deaths in Australian waters. Death may follow in 3-8 minutes after contact.

Less dangerous, but still painful, are the stings of the **sea nettle** (e.g., Dactylometra quinquecirrha) and the **sea blubber** (e.g., Cyanea capillata). The sea nettle is a widely distributed form which has been found as far north as New England coastal waters, as well as in all tropical sea areas. Sea blubbers inhabit areas from the north Atlantic and Pacific Oceans to the Arctic Ocean. Sea bladders increase in size in northern

latitudes. The Carolina Cyanea are about as wide as saucers; those off southern New England may measure one to two feet across; and farther north the Arctic specimens approach gigantic sizes.

Sea Anemones and Corals

The sea anemones and corals include venomous members which may produce sting symptoms when contacted. The sponge fisherman's disease, for example, has been found to be caused by the tentacles of very small sea anemones which adhere to the sponge, and not by the sponge itself. Although some forms of coral produce only lacerations, others, such as elk horn coral (Acropora palmata), which inhabits the Florida Keys, Bahamas, and West Indies, produce added reaction by means of stinging cells.

Preventive Measures

Rubber suits or tight-fitting coveralls (including the recently available Lycra nylon body suits) have proven to be useful protection. However, avoidance of contact with the tentacles is most important. Divers must be able to identify the dangerous species. They should also avoid detached tentacles floating in the water and dead jellyfish found on the beach, since the nematocysts may remain potent for some time.

First Aid for Marine Life Stings

The first aid procedures recommended for **common non-fatal jellyfish and hydrozan (Portugese man-of-war) stings** that are considered non-life threating in healthy individuals vary with author and geographic area. If no other rinsing solutions are available, the injured area should immediately be flushed with **seawater** and cleaned of debris. Many authorities suggest liberal use of a solution with high alcohol content (e.g., isopropyl rubbing alcohol: 40%) instead of sea water since it **allegedly** immediately inactivates the nematocysts. Formalin has also been considered effective. Other inactivating solutions cited in various publications include household ammonia, urine, petroleum products (gasoline, kerosene, etc.), and beer.

Never rinse the sting area with fresh water to remove tentacles. Freshwater has an osmotic effect on the nematocysts causing them to discharge. Beer apparently has the same effect as fresh water. Also, never rub the area with sand since this procedure will cause discharge of more nematocysts. Most authorities also discourage the use of petroleum products.

Recent research at James Cook University (Australia) and by the Royal Australian Navy School of Underwater Medicine has revealed that application of methylated spirits, 100% alcohol, and alcohol mixtures with seawater **produced dramatic,**

instantaneous discharge of the nematocysts, and this was associated with increased clinical sensitivity [13]. The James Cook University group found that the application of 3% to 10% acetic acid (or vinegar) was most effective in preventing the massive discharge of nematocysts associated with the application of alcohol and other common solutions tested. Further studies by Carl Edmonds, M.D., of the Diving Medical Center in Australia (one of the foremost world authorities on marine life injuries) concluded that **vinegar** and Xylocaine (lidocaine) will prevent further nematocysts discharge. Surprisingly, Edmonds also found that selected commercial preparations, anti-sting lotions, and the enzymatic product, Adolf's meat tenderizer were **clinically ineffective** [13]. The same was found for other common solutions such as urine, household ammonia, and so on.

Next, the tentacles that didn't rinse off must be carefully removed with a towel, stick, knife blade, etc. These residual tentacles may also be removed by coalescing them with a drying agent (e.g., flour, baking soda, talc, etc.) and then scraping them from the skin with a thin knife blade. **Avoid** personal contact with the tentacles.

After tentacles have been removed, some authors recommend neutralizing the toxins by applying one of the compounds/solutions mentioned above and thoroughly scrubbing with an antibacterial soap and water. The sting site is dried and an analgesic-antihistamine ointment applied. To the contrary, Australian authorites specifically state that the affected area must **not** be washed with soap and water for 24 hours [3,32].

Local anesthetic ointments (lidocaine HCl) or sprays (Benzocaine, 14%), antihistaminic creams, or mild steroid lotions (hydrocortisone, 1%) may be soothing [6]. They are used after the toxin is inactivated. A lidocaine spray (Clinicaine by Johnson and Johnson) may be beneficial as an initial decontaminant agent as well as a soothing solution [personal experience].

Observe the victim for general reactions and shock. It is advisable to lay the victim down and keep him/her as quiet as possible. The symptoms of **shock** include glassy eyes with dilated pupils; wet and clammy skin; weak and rapid pulse; pale or ashen skin tone; increased breathing rate (shallow or deep and irregular); and sensations of coldness [1]. First aid measures for prevention and management of shock [1] include keeping the victim lying down and covered **only** enough to prevent loss of body heat. No attempt should be made to add heat since raising the surface temperature of the body can be harmful. Elevate the feet or end of stretcher 8 to 12 inches. Giving fluids by mouth has value in shock; however, fluids should only be given when medical assistance is not available within a reasonable amount of time (delay of more than one hour). Fluids **should not be given** when the victim is unconscious, vomiting/likely to vomit, or experiencing seizures, since such states may result in aspiration

of fluids into the lungs. Water that is neither hot nor cold (preferably a salt-soda solution, 1 level teaspoon of salt and 1/2 level teaspoon of baking soda per quart of water) is given at about 4 ounces every 15 minutes. Do not give the victim sea water. Discontinue fluids if the victim becomes nauseated or vomits. Obtain medical assistance as soon as possible.

Simple pain relief measures (e.g., aspirin tablets, or equivalent, in accord with dosage instructions on container) are considered acceptable. Do not attempt to administer medications if the victim is unconscious or nauseated/vomiting.

Naturally, all stings will not result in severe reaction or shock and require such aggressive first aid measures. For example, fire coral encounters do not involve tentacle removal, and some small jellyfish stings give only minor, momentary irritation. After minor encounters the diver may continue to dive. However, the victims and their buddies must maintain an **awareness** for more serious reactions. In rare cases, respiratory or cardiac arrest may occur and require immediate life saving action.

The **box jellyfish** or **sea wasp** (Chironex flecheri) found in Australian and South East Asian waters is one of the most dangerous stinging animals in the world. Although records are far from complete, at least forty fatalities have been documented on Australian beaches [32]. Examination of records show that one-third of the fatal cases are said to have died within three minutes or less following encounter. If death does occur, it usually does so within the first ten minutes; survival is likely after the first hour [12]. However, the historical "death within seconds" phenomenon is now questioned by modern authorities. The fact remains that death can occur within minutes and immediate first aid is required. A specimen 7 cm in diameter is capable of killing a healthy child, while a specimen 10 cm or larger in diameter may kill an adult. In any event, contact with a sea wasp can result in excruciating pain, occurring immediately upon contact, and increasing in intensity. The victim may become confused, act irrationally, and, subsequently, drown.

The first aid procedures discussed below are summarized primarily from Australian literature [3,12,32]. **However**, in accord with more recent research, vinegar or Xylocaine-containing spray has been substituted for alcohol (or methylated spirits) [13]; Auerback and Halstead recognized the use of either alcohol or vinegar in their 1983 publication [6].

Since serious, potentially fatal reaction can be anticipated within minutes, the victim must be removed from the water immediately. **Avoid** personal contact with any adhering tentacles. If at all possible, do not allow the injured area to come into contact with sand or boat surfaces. Such contact may bring more

stinging cells into contact with the skin and cause the release of more venom. **Immediately** and **thoroughly** douse the sting area and tentacles with liberal amounts of vinegar (or Xylocaine spray).

Isolate the envenomed part, if on limbs, from general circulation as soon as possible. Several Australian authorities and publications indicate that a tourniquet should be applied in the middle of the upper arm or thigh above the injury using the most suitable form of binding applied at a pressure sufficient to stop the flow of blood (pulse). This should be kept in place for 1.5 hours or until antivenin has been given, medical attention received, and/or the patient is conscious and breathing normally [3]. Most United States authorities on first aid maintain that once applied, the tourniquet should be removed only by medical personnel since "shock" caused by loosening a tourniquet can, in itself, be fatal. Note the time of day that the tourniquet is applied.

Keep in mind that first aid authorities in the United States specifically discourage the use of tourniquets except when absolutely necessary. For example, in the management of poisonous snakebites a constricting band applied with only enough pressure to reduce lymphatic flow, not blood flow, is recommended. **The decision to apply a tourniquet is in reality a decision to risk sacrifice of a limb in order to save a life!**

In a more current publication, Auerback and Halstead recommend the immediate application of a "loose tourniquet" which only impedes the lymphatic and superficial venous return. This "loose tourniquet" is loosened for 90 seconds every 10 minutes and should be removed after one hour [6].

Respiratory failure is possible. The victim must be monitored continuously and artificial respiration begun immediately if the victim stops breathing; cardiopulmonary resuscitation may be required if there is no obvious pulse. Do not delay or interrupt this aspect of first aid for any reason if an unconscious victim requires it. Do not terminate resuscitation procedures until directed to do so by medical personnel or as indicated in accord with ARC/AHA procedures. **Oxygen breathing** is recommended if the equipment is available.

Remove any remaining tentacles by irrigating the area with more vinegar. Do not handle or rub the tentacles unless removal by irrigation technique is unsuccessful.

Send for medical assistance and antivenin as soon as possible. Australian literature specifically discourages moving a seriously affected victim. Maintain constant observation and keep the victim quiet even if his/her condition improves significantly. Transfer responsibility for the patient to qualified medical personnel upon arrival.

The Commonwealth Serum Laboratories have developed an antivenin for stings of the sea wasp, and sublethal stings have been successfully treated. Australian scientists have investigated the use of toxoid that will provide immunization against the sting.

Sponges

There are approximately 4000 species of the phylum Porifera, or sponges, of which a few can produce a serious dermatitis or skin irritation. Keep in mind that many sponges may be colonized by other sponges, coelenterates, and numerous other organisms. Contact with the sponge can result in coelenterate stings. Skin reactions termed **sponge diver's disease** are often attributed to these secondary inhabitants. A few sponges can induce either pruritic (itching) or irritant dermatitis.

The **fire sponge** (Tedania ignis), found off Hawaii and the Florida Keys, and the **"Do-Not-Touch-Me" sponge** (Neofibularia nolitangere), common to the Caribbean, are typical offenders. Reactions are characterized by itching and burning, which may progress to local joint swelling, blisters, and stiffness. Soaks in dilute (5%) acetic acid (vinegar) are considered beneficial [6].

Most sponges are composed, in part, of small silicon dioxide or calicum carbonate spicules. These spicules are tiny and difficult to detect with the naked eye. If penetration of the skin by these small spicules is suspected, the particles may be removed by gently applying adhesive tape to the injured area and then removing it. Many of the embedded spicules will adhere to the tape during removal. Toxic sponges may possess toxins which will enter the lesions caused by the spicules. Application of isopropyl alcohol or vinegar should follow this removal procedure. Steriod lotions may help to relieve secondary inflammation. Severe secondary reactions may require medical attention.

MARINE ANIMALS THAT ABRADE, LACERATE, OR PUNCTURE

A number of marine organisms cause abrasions, lacerations, or punctures when contacted by the diver. Some of these organisms possess venom injection structures and may cause serious complications.

Coral

Wounds inflicted by contact with stony coral are an ever present annoyance to divers in the tropics. The sharp calcareous edges produce wounds which are generally superficial but notoriously slow to heal. Coral cuts, if left untreated, may become ulcerous. Sting cells may further complicate conditions.

The initial effects of coral poisoning are pain and an itching sensation in and around the wound accompanied by reddening and welt formation in the surrounding areas. Secondary infection is common.

First aid involves prompt removal of visible debris and cleansing of the wound with hot water and antibacterial soap. It is occasionally helpful to use hydrogen peroxide to bubble out coral "dust." Promote free bleeding; however, keep in mind that excessive probing can cause unnecessary tissue damage. Deeply embedded materials may require removal by a physician. Elevation of the involved limb is strongly recommended. The use of antiseptic creams is a matter of personal preference. Monitor the wound closely and cleanse/change dressings as soon as possible upon return from subsequent dives. Even minor wounds can become seriously infected. Current tetanus immunization is recommended for all divers. For severe wounds, or if complications appear, seek immediate medical attention. Divers are encouraged to wear canvas or leather gloves and diving suits or cloth coveralls for protection when swimming in the vicinity of coral.

Barnacles

Barnacles, a marine arthropod, in the adult shell form are found attached to rocks, timbers, ship hulls, etc., in and near the intertidal zone. These shells are sharp and especially hazardous to divers who must enter the water from rocky shore areas, work on ship hulls near the waterline, or dive around pilings or offshore structures such as oil rigs. An abrasive injury may be further complicated by the presence of hydroids on and among the barnacles. Caution and protective clothing are recommended. First aid measures are the same as for coral lacerations.

Echinoderms

Most members of this group of marine organisms are characterized by radial symmetry and may bear a rigid or semirigid skeleton of calcareous plates or spines on a flexible body way. Included are starfishes, sea cucumbers, and sea urchins. Of all echinoderms, the sea urchins are probably responsible for most injuries to divers.

Sea urchins occur in large numbers and variety in the shallow coastal waters of the world. The spines, common to all sea urchins, vary greatly from species to species. Most spines are solid, with blunt or rounded tips, and are not venomous. Others, however, are long, slender, sharp, and brittle, permitting easy, deep entrance into the flesh. Because of the extreme brittleness, these spines may be difficult or impossible to withdraw in one piece. Some may secrete a painful, or even deadly, venom. In some species, small, delicate, globe-shaped

seizing organs called pedicellariae are distributed among the spines. This globe-shaped head, in at least one type, serves as a venom organ and is armed with a set of pincer-like jaws. One such venomous genus, Toxopneustes, inhabits the Indo-Pacific and Japanese waters. Symptoms vary from radiating pain to paralysis and respiratory distress. Fatalities have been reported.

More familiar to the United States diver is the genus Diadema, which includes the long-spined or black sea urchin common to the Bahamas, Florida Keys, and West Indies. These sea urchins with long, brittle spines are not considered to be a serious hazard by most divers; however, they may produce a painful puncture-type wound with redness and swelling. The fragments of the spine will produce a purple discoloration in the area of the wound. In minor injuries, the spines of some species will dissolve with few complications besides localized discomfort. However, deeply embedded spines will cause irritating discomfort of long duration if not removed. These should be removed with a fine tweezer or small needle (sterilized), the area thoroughly scrubbed with hot water and antibacterial soap, and a sterile dressing applied. Medication to control pain, inflammation, and infection may be required. Consult a physician immediately if symptoms of infection or other complications appear. Surgical removal of deeply embedded spines may be necessary.

Sea urchins with long needle-like spines should not be handled. Ordinary foamed-neoprene, canvas, or leather gloves do **not** afford adequate protection. Divers must exercise extreme caution, especially at night.

Some sea urchins are venomous. It appears that those which can cause serious reactions in a human are more common to the South Pacific. One genus, Tripneustes, found in the Pacific Ocean, has a neurotoxin. Injury from the pedicellariae (small, delicate seizing organs scattered among the spines of some species) can cause serious reactions. The symptoms may include immediate intense radiating pain, local swelling, and hemorrhage. This may be accompanied by faintness, numbness, generalized muscular paralysis, loss of speech, respiratory distress, and occasionally death [6]. In such cases first aid/treatment is in accord with the severity of the symptoms. Hot water may provide pain relief [6]. Seek medical attention immediately in the event of such severe reactions.

Some species of **starfish** can produce a contact dermatitis from a slimy venomous substance produced in the animal's tissue. The "crown-of-thorns sea star" (Acanthaster planci) is a particularly venomous species found from Polynesian waters to the Red Sea. Envenomation can induce acute systematic reactions that include paresthesia (sensation of prickling and tingling), nausea, vomiting, and muscular paralysis. First aid measures include immediate application of hot water and subsequent use of a topical solution such as calamine with 0.5% menthol. Medical attention may be required for serious reactions [6].

Cone Shell

The family of marine gastropod Conida is comprised of more than 500 species distributed throughout the tropical seas of the world, but concentrated in the reef areas of the Indo-Pacific. Some species are highly valued by collectors, with Conus gloriamaris being worth more than $1,000 per specimen. Every species of Conus makes a venom peculiar to that species, and most have a fully developed venom delivery apparatus near the shell opening. Radular teeth are thrust into the victim, and the venom is believed to be injected under pressure into the wound. The venom of a given species of Conus may only affect certain animals and be totally ineffective on others. Only about six species of Conus are considered deadly to man. Conus geographus has been officially indicated in human fatalities and other species such as Conus magus are just as deadly.

The sting of a Conus usually produces a numbness, tingling, or burning sensation which may spread rapidly and become particularly pronounced about the lips and mouth. Paralysis and coma may follow. Death from respiratory or heart failure may result. Unfortunately, many authorities list no specific treatment for cone shell injuries. Some manuals suggest that cone shell injuries be managed the same as venomous fish injuries. Edmonds suggests that the use of a constricting band with incision and removal of venom, as in the treatment of a snake bite, may be of value if performed early [12]. This procedure is also supported by other authorities [6,32]. In light of the recommendations in the literature, the procedure given below should be considered in the first aid management of cone shell injuries.

The first-aider should immediately immobilize the victim and take measures to combat shock. Elevate the affected limb if possible. Apply a venoconstrictive tourniquet or constricting band sufficient to reduce lymphatic and superficial venous return [6]. Sterilize area (and instrument) and make a small incision over the wound. Suction (using components of a snakebite kit, not by mouth) may be applied to promote bleeding and remove poison. This procedure should be started as soon as possible. Soaking the site of injury in hot water or applying hot compresses for 30 minutes can be effective in inactivating the venom and reducing pain or other symptoms. Paralysis and respiratory/cardiac failure may occur. Make routine observations of respiration and circulation continuously. Employ resuscitation or CPR if and when indicated. Immediate medical attention and hospitalization is generally required.

Specific precautions and ample protection for the hands are necessary when handling cone shells. Avoid contact with the fleshy portion of the animal. Divers must learn to identify dangerous species peculiar to their locality, and specific precautions must be taken in Indo-Pacific waters.

Venomous Fish

Fish that inflict poisonous puncture-type wounds are found throughout the world, but are most common in tropical waters. They are generally nonaggressive, and injury generally results from careless contact with venom-bearing spines, commonly located on or associated with the fins of the fish.

The common **spiny dogfish** is a small (up to 3.5 feet in length) shark found along the coast of the Atlantic and Pacific Oceans throughout temperate and tropical seas. Two short, stout spines, one situated immediately in front of each dorsal fin, can cause painful wounds. The venom is found in a shallow groove of the spines and enters the victim with the spine. Injury is immediately followed by an intense, stabbing pain of long duration (possibly 6 hours), severe swelling, and redness. Handle dogfish with caution.

Stingrays of many kinds inhabit tropical and subtropical seas at moderate to shallow depths. They are common in sheltered sandy bays and lagoons where they lie in shallow water on top of or partially buried in the sand or mud. Most rays have a sharp spine near the base of a whip-like tail. Deep, glandular grooves of the spine contain poisonous tissue. The menace is most serious to persons wading or crawling on the bottom in very shallow, protected waters. When stepped on, the ray strikes upward with its tail and may drive the spine deeply into the foot or leg. This usually produces a ragged, dirty wound. The wound usually causes immediate and severe pain. Swelling of the wound area is accompanied by an ashy appearance which later turns red. Symptoms of shock along with fainting, nausea, and weakness may follow, depending on the severity of the injury and the species of stingray. Medical attention is recommended. Wounds in the chest or abdomen are extremely serious and may be fatal. Deaths have been reported. Immediate hospitalization is necessary.

The diver can avoid contact by entering the water cautiously and shuffling his feet as he moves through shallow water and never lying on the bottom without first looking for rays. Fins and foamed rubber boots offer only limited protection.

About 1,000 species of **catfish** are found primarily in fresh water and may assume many sizes and shapes. Generally, the body is elongated with oversized head, and the mouth area usually has long barbels or feelers. The skin is usually thick and slimy, without scales, although bony outer plates may exist in some.

Some species have a stiff spine in the front part of the dorsal and pectoral fins. Venom glands are located in the outer skin or sheath of the spine. The venomous spine is equipped with a device which can lock it into an erect position. The wound is generally accompanied by an almost instant stinging, throbbing, or scalding sensation, with radiating pain and numbing; redness and swelling follow. Bacterial infection is possible. Care must be taken to avoid injury when handling venomous species.

Weeverfish, of the family Trachinidae, are small but extremely venomous fish found along the **eastern** Atlantic and Mediterranean coasts. Because of an **aggressive** temperament, combined with a well-developed venom apparatus, they present a specific danger to divers. Weevers habitually bury themselves with only part of the head exposed. With little or no provocation, they dart out with fins erect and gill covers expanded and strike at any offending target.

The dorsal and opercular spines are venomous. This venom is similar to some snake venoms and acts both as a neurotoxin and a hemotoxin. A weever wound normally produces instant burning or stabbing pain that intensifies and spreads. Within 30 minutes the pain may be severe, and the victim may lose consciousness. A large spectrum of symptoms includes headache, fever, chills, delirium, nausea, vomiting, sweating, palpitations, and convulsions.

Weevers are commonly encountered while wading in shallow water; care must be taken to avoid contact. Adequate footwear (high-top tennis shoes) may provide some protection. This fish should neither be antagonized into an attack or handled in a careless manner.

The members of the **scorpionfish family** can be found in all tropical and temperate seas. The wound from any of these fish will produce serious results, and a few of the stonefish group, Synanceja, may rank with the cobra in the deadliness of the poison secreted. Most species have venomous dorsal spines; some have venomous anal and pelvic spines. These fish are divided into three main groups:

1. scorpionfish (Scorpaena)
2. zebrafish (Pterois)
3. stonefish (Synanceja)

Scorpionfish inhabit shallow-water bays, lagoons, and reefs--and have also been observed 60-80 feet deep in the waters of the Bahamas. Scorpaena gutlata ranges from central California south into the Gulf of California and Scorpaena plumieri (and related species) are found on the Atlantic coast from Massachusetts to the West Indies and Brazil. They may be found among debris, rock, or seaweed. Scorpionfish have nearly perfect protective coloration which enables them to blend into their background and become almost invisible.

Zebrafish are beautiful and ornate fish which swim about coral reefs of the Red Sea and Indo-Pacific seas with their fan-like fins extended in a display fashion. Although extremely beautiful and prized by fish collectors, the fins of this fish contain 18 potentially lethal spines, each equipped with venom.

Stonefish are encountered in tidepools and shoal areas of the Indo-Pacific [16]. They lie motionless while concealed or partly buried and appear to be fearless. The fish is equipped

with as many as 18 spines with enlarged venom glands. In natural concealment, the fish looks like a piece of mud or debris. They present a particularly dangerous hazard to a bare-footed wader.

Other fish which may inflict venomous wounds include toadfish, surgeonfish, dragonets, rabbitfish, and star-gazers. For a detailed account of these fishes, consult Halstead (18,20).

Prevention of injury from all venomous fish is based on the diver having a healthy respect for the potential serious wound, being aware of the habits of particular species common to the waters in which he is swimming, and being alert and observant to avoid contact with concealed or camouflaged fish. **When diving in an unfamiliar area, it is recommended that divers consult with local authorities.**

First aid for venomous fish wounds includes alleviating pain, combating shock and the effects of the venom, and preventing infection. Since unconsciousness is common, the victim should be removed from the water promptly. Pain will be severe. Have the victim lie down and apply measures to prevent/combat shock. Keep the affected limb level with the body and as still as possible to minimize the spread of venom. Carefully wash out or irrigate the wound with cold salt water or with sterile saline. Although the use of a tourniquet is indicated in some manuals, the practice is considered to be of limited value [12,17]. However, Auerbach and Halstead do indicate that the application of a "loose tourniquet" which occludes only superficial venous and lymphatic return may be of some value [6]. This "loose tourniquet should be released for 90 seconds every 10 minutes in order to preserve circulation. Considering the inherent risk associated with the use of tourniquets, this practice is generally discouraged for first aiders. Attempt to remove any remaining portions of the spine sheath.

Soak in plain water, as hot as can be tolerated (up to 50° C/122°), for at least 30 minutes. Use hot compresses on areas that cannot be immersed. Heat may produce rapid pain relief and is believed to destroy the venom. Be careful not to scald the tissue. Immersion in hot water appears to be the **most important** first aid procedure for venomous fish injuries universally agreed upon by authors/authorities.

Although some diving manuals recommend that the first aider make a small incision at the site to encourage bleeding and facilitate irrigation, Halstead [17] indicates that the incision may be of limited value, and Edmonds [12] indicates that a small incision can be made across the wound and parallel to the axis of the limb, to encourage mild bleeding, and pain relief **if other methods are not available.** In light of modern trends in first aid and the potentially limited value of the incision method indicated by physicians, this author is inclined to not recommend this procedure unless future evidence supports its benefit.

Visible foreign material should be removed. Auerbach and Halstead suggest that local suction may be of some value, however, they do not indicate the use of incision [6]. Medical attention will be needed for further treatment of the wound and prevention of infection.

MARINE ANIMALS THAT BITE

Moray Eels, family Munaenidae, are represented by about 20 species and are confined primarily to tropical and subtropical seas, although several temperate-zone species do exist in Californian and European waters. Morays dwell mostly on the bottom in crevices and holes under rocks or in coral. They possess powerful jaws with strong, sharp teeth capable of inflicting severe lacerations. The morays seldom attack unless provoked; however, several unprovoked attacks have occurred. Their bite is of the tearing, jagged type.

The diver should exercise due diligence and caution when exploring crevices and holes in areas where morays are known to exist. A moray should not be agitated. Though some divers successfully hand-feed morays, this activity is not recommended. In some dive resort waters moray eels aggressively approach divers in search for a "handout." If approached, do not strike at the eel; remain calm, do not hold out your hand as if offering food. A moray may become aggressive in defense of its territory.

Barracuda

Barracudas are potentially dangerous fish found widely distributed throughout the tropical and subtropical waters of the Atlantic and Indo-Pacific. Their size (which may exceed 6 feet); knife-like, canine teeth; and failure to exhibit any undue fear of man have earned barracudas the false reputation of an extremely pugnacious and dangerous fish that will attack rapidly and ferociously. Although several spearfishermen have been severely injured when attempting to handle speared barracuda, it must also be noted that there are few, if any, documented **unprovoked** barracuda attacks on divers.

Barracudas are curious fish that may be attracted by excessive movement, bright or colored objects, and, particularly, shiny metal objects that reflect light (i.e., jewelry). It is not unlikely that a barracuda would strike at a speared fish. This is a particular hazard for spearfishermen who carry fish on a stringer attached to their belts. The potential of an accidental encounter with subsequent injury is probably higher in murky water where the barracuda is less likely to see the entire diver and strike at a portion of the diver or the movement which resembles prey.

Prevention of attack appears to be one of respect and caution when diving in waters inhabited by barracuda. Divers should avoid wearing bright or shiny objects. Unnecessary agitating and hand-feeding of barracuda are discouraged, as is spearing.

Sharks

Sharks are probably the most feared of all marine animals. There are about 250 species of sharks which inhabit all the oceans of the world; however, only 32 have been implicated in attacts on humans and are considered potentially dangerous to divers and underwater swimmers. There are considerable differences of opinion regarding the potential risk of a shark attack. Myth and public opinion fostered by popular film productions such as "JAWS" has resulted in unwarrented anxiety for many novice divers. There are only 50 to 100 shark attacks reported annually worldwide [8]. Cross (1967) gives the following figures on the frequency of shark attacks. During 1959 there were 11 authenticated attacks in the vicinity of the United States, of which three were fatal. By comparison, in the same year in the United States there were over 400 people killed by lightning and another 1,000 injured. In 1960, there were 42 reported shark attacks on humans throughout the world; none were fatal. Of all reported shark attacks during these two years, none have involved helmet-equipped divers, and only a few have involved scuba divers. Almost all attacks have been on swimmers, waders, or persons dangling their arms or legs from surface floats or rafts. **However, in more recent years the incidence of shark attacks on scuba divers appears to be progressively increasing and now accounts for one-third of all shark attacks [12].**

Statistically, the greatest danger of shark attack exists in tropical and subtropical seas, between 30 degrees north and 30 degrees south of the equator. Particularly dangerous areas are Queensland, Australia, and South Africa. Seventy percent of all the attacks have occurred within 5 feet of the surface and 62.2 percent within 300 feet of shore. Most attacks have occurred when the water temperature was greater that 70° F, with January as the peak attack month in tropical waters. The greatest risk appears to be between 1500 and 1600 hours (3:00-4:00 pm).

Sharks appear to be attracted by blood (fish or human), flashing lights, colored material, thrashing about, explosions, or unusual noises. The presence of blood highly excites sharks and may radically alter their normal habits. The diver is certainly in most danger if he is injured, bleeding, or carrying speared fish that are bleeding. Sharks apparently have a well-developed sense of smell and will "home in" on blood. They have unique sensory mechanisms which enable them to hear (feel) vibrations from a considerable distance. Thus, they are more apt to "home in" on surface splashing or underwater noises. Erratic, panic-like movements executed by a frightened swimmer are believed to excite sharks and increase the probability of attack.

In spite of differences of opinion about many aspects of sharks, all authorities agree that **sharks are completely unpredictable.** Although sharks usually seem aloof and quiet, they can become viciously aggressive, and for no apparent reason. Although nurse sharks, sand sharks, and leopard sharks are considered harmless by some divers, attacks have been reported. A University of Michigan scientist was bitten on the leg during July 1972 while diving in the Florida Keys; the attack was without warning or provocation.

Many opinions have been expressed on how to chase sharks away; however, it has been fairly well established that procedures such as shouting underwater, blowing bubbles, striking on SCUBA cylinders, striking rocks together, or, if on the surface, splashing with a cupped hand will not frighten a shark. In fact, it is believed by some authorities that these actions will actually attract sharks. Although several chemical and electronic shark repellents have been developed and used with some success, most authorities feel that there is still no guaranteed effective repellent.

Many divers use a pole (4-8 feet) equipped with an explosive power head for protection or to kill sharks. The power head consists of a chamber and firing device which detonates a 12-guage shotgun shell or 38- to 45-caliber bullet when pressed against the target. This type of weapon is popular in Australia and said to be extremely effective in killing sharks. A certain degree of accuracy is required to hit the shark behind the eyes and dead center over the base of the spine for an effective kill. A wounded shark may be more dangerous, and the blood and thrashing movements may attract more sharks. The power head is also an extremely dangerous weapon, and accidental firing could result in considerable injury to the diver or other swimmers. Some authorities feel that the hazard of the weapon is greater than the hazard of shark attack. Keep in mind that some states and countries have strict laws regulating the possession and transport of firearms and that some authorities may consider such devices to be illegal.

Many authorities advocate the use of a **"shark bully,"** constructed to meet personal preference. This defensive weapon consists of a short pole (3-4 feet) made of hardwood, metal, or weighted plastic with a blunt end fitted with a roughened material to prevent slipping on the shark's skin. The best place to strike an aggressive shark is on the snout, or nose. The strike or blow should be as hard as possible. This blow may discourage the shark, and the reactive force pushes the diver aside as the shark passes.

Some divers prefer the use of a **gas injection device** or "shark dart" [24]. The device consists of a CO_2 cylinder contained in the holder; a firing mechanism; a sharply pointed, stainless steel, 5/16-inch, hollow needle; and a pole (length varies depending on the model). The size of CO_2 cylinder also varies with the model. This weapon is effective to depths of 25

feet with a 12-gm CO_2 cylinder, 40 feet with a 16-gm cylinder, and 100 feet with a 26-gm cylinder. A multiple-shot, compressed-air model is also available. Divers must handle these devices with care in order to prevent injury to themselves or others. Keep in mind that a gas injection weapon may also be subject to local laws and regulations. For example, under strict interpetation of Michigan law, a shark dart (gas injection weapon) is illegal to possess.

To disable a shark, the diver thrusts the needle of the shark dart into the shark's abdominal area. The needle easily punctures the skin and, subsequently, the CO_2 cylinder is punctured by the firing mechanism, and the gas is released. This small volume of high-pressure gas entering the shark suddenly displaces the water inside him and forces it to take the path of least resistance. The pressure wave reverberates throughout the shark, blows the stomach out his mouth, and destroys his internal organs. The expanding gas forces the shark to the surface. He is instantly immobilized.

When diving in water known to be inhabited by sharks, the diver should observe the following:

* Avoid solo skin or scuba diving. Visual sighting and early warning will allow the divers time to leave the water at signs of aggression. One of the two divers is more apt to sight the shark immediately. Also, in the event of an attack, help is immediately available.

* The diver should leave the water immediately if injured or bleeding.

* Diving or swimming in turbid, shark-infested waters should be avoided, if possible. A portion of a diver's leg and fin might have the appearance of a fish on which the shark would feed whereas a fully visible diver might be discouraging. Moreover, if the diver is aware of the shark's presence and activities, he has a better chance of taking defensive measures, if necessary.

* Light-colored clothing and bright, flashing equipment are more likely to attract sharks according to some authorities and should be worn with caution or avoided in high shark risk areas.

* Panic must be avoided if a shark is sighted. Half the battle of shark safety is over once the shark is sighted. Rapid movements or immediate ascent to swim on the surface may excite the shark and cause it to move in and investigate. The diver should remain calm and face the shark. If the shark appears to simply be passing by (most of them do), leave it alone. If the shark moves in

and is persistent, the diver should stay on the bottom and move slowly and quietly out of the area, preferably toward the boat or other safe place (i.e., shark cage). The diver should not surface but stay on the bottom as he moves toward his boat position. Safe refuge may be sought in a crevice or behind rocks.

* The diver should never attempt to wound the shark with a spear gun or knife. These actions are virtually useless and may make matters worse.

* Teasing and spearing sharks is discouraged. They are difficult to kill and can react in a fantastic frenzy if hurt.

* Speared fish should never be carried on a stringer attached to the diver.

* A "shark bully" or "shark dart" is recommended for defense in areas of exceptionally large shark populations or where sharks are noted for aggressive behavior. Striking a shark with the bare hand can result in lacerations and bleeding.

* Divers should not dangle arms and legs from surface floats.

* Since the shark is unpredictable, he must be respected, and the diver must be prepared to abort the dive in some instances.

The diver should not give up diving just because there are sharks in the ocean. He should learn to respect them, not fear or dislike them. For additional information about sharks and shark attacks, consult Gilbert [15], Cross [9], Baldridge [7], and the U.S. Navy [29,30].

Killer Whale

The killer whale, Orcinus orca, is found in all seas and oceans from the Barent Sea or Bering Straits to beyond the Antarctic Circle. This species is characterized by a bluntly rounded snout; high, black, dorsal fin; white patch behind the eye and a striking jet-black color above the eye; and contrasting white underparts. They are swift swimmers with a reputation of being ruthless and ferocious killers. Killer whales are reported to hunt in packs and are serious enemies of the seal, walrus, and penguin. In spite of recent notoriety of trained killer whales in marine exhibits/seaquariums and various published pictures of divers riding them in the ocean, they must still be considered an unpredictable, potentially serious hazard. They should be treated with respect and at a distance. A human, mistaken for a sea lion, would be a nice snack for a killer whale. Divers are

encouraged to leave the water immediately when killer whales are sighted in the area.

First Aid

Injuries inflicted by moray eels, barracuda, and sharks are generally severe lacerations with profuse bleeding. First aid procedures for controlling bleeding and subsequent shock should be started immediately [1]. Prompt medical attention will usually be required.

MARINE ANIMALS THAT HAVE VENOMOUS BITES

Octopus

Along with squid, nautilus, and cuttlefish, the octopus belongs to the class Cephalapoda, phylum Mollusca. The octopus has a powerful, parrot-like beak concealed in the mouth, and, in some species, a well-developed venom apparatus associated with the salivary glands. Because of public notoriety and myth, the octopus is vastly over-rated as a hazard. Actually, the octopus is timid and prefers to stay concealed in holes. In the northwestern United States, skin and scuba divers actually hunt large octopi (up to 20 feet in overall length) and "wrestle" them for sport. Certainly, some precautions are required if the octopus must be handled; heavy gloves are recommended. In Florida and the Bahamas the octopi are much smaller, generally not exceeding 2 feet in length.

The bite is similar for all species and usually consists of two small puncture wounds. A burning sensation with localized discomfort may later spread from the bite. Bleeding is usually profuse, and swelling and redness are common in the immediate area. First-aid measures include scrubbing the bite with antibacterial soap. Measures to combat shock should be taken, and medical attention may be required. Recovery is fairly certain.

The Australian **blue-ringed octopus** (Octopus maculosus) and **spotted octopus** (Octopus lunulatus) could inflict a **fatal bite.** The blue-ringed octopus is being found in ever increasing numbers off the beaches of South Queensland and other areas of Australia, and several fatalities have been recorded [10,19]. It rarely exceeds a length of 4 inches, and has dark brown to ocher bands over the body and tentacles. Brilliant blue circles are scattered over the animal. The venom of this octopus is a neurotoxin and a neuromuscular blocker which can cause painless muscular paralysis.

The initial bite is usually painless and may go unnoticed. The area around the bite will begin to swell within 15 minutes, and the victim will experience abnormal sensations around the mouth, neck, and head; mouth dryness; nausea and/or vomiting;

visual disturbances; respiratory distress; and a variety of neurological disorder symptoms. The victim's conscious state is initially normal, even though he may not be able to open his eyes or respond to his environment. Respiratory paralysis finally results in unconsciousness (as a result of hypoxia and hypercapnia) and death occurs unless resuscitation procedures are begun and continued.

If the victim is still breathing, immediately have the victim lie down and immobilize the limb. Apply a constricting bandage between the wound site and the heart [12] and make a small incision over the wound to encourage bleeding and venom removal [12,32]. Take appropriate measures to prevent/manage shock, and place the victim on his side in case of vomiting. **Maintain the victim under constant observation!** Be prepared to begin mouth-to-mouth artificial respiration if respiratory paralysis occurs. Artificial respiration may have to be continued for hours and CPR may be necessary. Reassure the victim who can hear but cannot communicate that he will be alright, and that you understand his condition. Transport to a hospital and/or obtain on-site medical assistance as soon as possible.

Sea Snake

About 50 species of sea snakes are found primarily in the tropical Indian and Pacific Oceans. At least one species is found on the Pacific coast of Central America and in the Gulf of California. The sea snakes are closely allied to the cobra and form a specialized group adapted by structure and habit to a marine existence. All are poisonous and many are deadly; however, they will generally not attack without provocation and have often been described as docile in habit although aggressiveness has been observed in some specimens. Only a few appear to be of significant danger to humans. They have been noted to be attracted by fast-moving objects such as divers being towed by boats [12]. Bites usually result from unintentional contact; fatalities are most common in the Gulf of Siam and the Philippine area.

Few sea snakes exceed a length of 4 feet. They are distinguished from land snakes by a paddle-shaped tail. Coloration is dark above and light below with cross-bands of black, purple, brown, gray, green, or yellow. They inhabit sheltered coastal waters, particularly the areas near river mouths, and may penetrate upstream to the limits of brackish water; a few species are found in fresh water. Sea snakes tend to collect close to shore and among coral reefs in breeding season. The sea snakes generally float on the surface for extended periods of time. Although they are air breathers, they are capable of remaining submerged for long periods.

The bite is usually small with considerable delay (average of 1 hour) between the injection of venom and the reaction. Some

victims fail to notice the connection between the bite and the illness since there is no pain or reaction at the site of the bite. Sea snake venom is approximately 2 to 10 times as toxic as that of the cobra; however, they tend to deliver less of it. Only about one-quarter of those persons bitten by sea snakes ever exhibit signs of poisoning [12]. Symptom onset progresses from mild to severe, generally beginning with an ill feeling or anxiety, thickening of the tongue, muscular stiffness, and aching. Later symptoms include shock, general weakness, paralysis, thirst, muscle spasms, respiration difficulties, convulsions, and unconsciousness. Deaths have been reported. Sea snake venom appears to block neuromuscular transmission, inducing generalized and painless skeletal paralysis. The diver should avoid aggravating the sea snake, and, in water known to be inhabited by the snake, he should be alert to avoid accidental contact. Wet suits will offer some protection since, in the average size snake, the mouth and fangs are relatively small.

First-aid measures include keeping the victim quiet, taking measures to combat shock, and applying a constricting band above the bite, if bitten on the arm or leg, with sufficient pressure to restrict superficial venous and lymphatic return (this band should not restrict arterial blood flow). Release the band for 90 seconds every 10 minutes and do not use for more than 4 hours [6,17]. Monitor the victim continuously and be prepare to begin artificial respiration/CPR if indicated. Transport the victim **immediately** to the nearest medical facility since antivenin treatment must be started as soon as possible. If possible, accurately identify the offending snake or capture and kill it for later identification. This is helpful for determining treatment procedures. For further details, consult medical references [6,12,18].

MISCELLANEOUS HAZARDOUS MARINE ANIMALS

Sea Lions

Sea lions and harbor seals are normally curious but nonaggressive as they swim about divers. There are reports of playful but potentially damaging "nips" and loss of a swim fin. During the breeding season, the large bulls become irritable and may take exception to any intruder. Also, a female may exhibit protective reactions toward a diver molesting her young. Divers have been bitten and should avoid ill-behaved animals. One California diver has indicated that a potentially greater danger when swimming with seals is that of being shot with a rifle by a person sitting on a cliff. Some divers wear bright markings on their hoods for this reason.

If bitten by a seal or sea lion, cleanse the wound with soap and water and be aware of the possibility of infection. The diver should consult a physician.

Giant Clam

The giant clam, Tridacna gigas, abounds in the reefs of Pacific tropical waters. Specimens may attain a length of 4 feet and weigh several hundred pounds. Some authorities claim that Tridacna have trapped divers by closing on a hand or foot with a vice-like grip. However, discussions with several scientists who have worked on the Great Barrier Reef of Australia indicate that "trapping of divers by giant clams" is questionable and probably fears are unfounded. In any event, the grip can be released by inserting a knife between the valves and severing the two adductor muscles which hold the valves together. The diver is, however, discouraged from experimenting with his own foot.

Groupers and Jewfish

Some species of giant grouper and jewfish may attain a length of 12 feet and weigh more than 700 pounds. They are frequently found around rocks, caverns, and submarine structures such as offshore oil rigs. These fish are not considered vicious but can be unintentionally dangerous because of their curious nature and huge size. One of the most interesting accounts of an aggressive jewfish is given by Zinkowski [33].

Annelid Worms

The segmented marine bristleworm, Eurythoe complanata, possesses tufted, silky, chitinous bristles in a row along each side. Upon contact or stimulation of any kind, the bristles rise on edge as a defensive mechanism. The fine bristles penetrate the skin and are very difficult to remove. This results in a burning sensation, inflammation, and possibly local swelling and numbness. Bristleworms are found in the Bahamas, Florida Keys, Gulf of Mexico, and throughout the tropical Pacific.

Bristles are best removed with forceps or, if exceptionally small, by applying tape to the area and gently removing. After removal, application of ammonia or alcohol will alleviate the discomfort. Divers should avoid contact or take special precautions in handling.

The bloodworm, Glycera dibrochiata, is found on the Carolina coast northward into Canadian waters. These worms, up to 12 inches long, may be encountered under rocks or coral. They possess strong jaws and may inflict a painful bite. Swelling, numbness, and itching follow the bite.

Electric Rays

Electric rays, or torpedo rays, grow from 1 to 6 feet in length and weigh up to 200 pounds. They may be found on both the Atlantic and Pacific coasts of the United States, as well as

other areas of the world. They are shaped somewhat like a normal sting ray; however, their wings are thick and heavy, and their tails are modified for swimming. The giant Atlantic torpedo ray can produce a current of 50 amp at 60 v, enough to electrocute a large fish or knock down a full-grown man. Needless to say, divers must be cautious when approaching or attempting to handle specimens from this group.

Sawfish

Sawfish are members of the ray family that have shark-like shapes and swim by sculling their tails. They are sluggish but powerful and commonly reach a length of 16 feet. The cartilaginous snout is extended in a long, flat "saw," equipped on both sides with sharp scales or denticles which have been enlarged into teeth. Large specimens have been recorded at a length of 22 feet with a 6-foot snout. The snout is swung from side to side to impale fish. The size and snout make this ray a potential hazard for divers; however, it is not likely to attack unless provoked. Caution is recommended.

Marine Turtles

Recently, divers in the Florida Keys have reported minor injuries resulting from aggressiveness by large marine turtles. Several divers were "nipped." Authorities feel that these "nips" were of a playful nature. Still, the size and power of a swimming turtle must be respected by the scuba diver.

Paralytic Shellfish Poisoning

Paralytic shellfish poisoning is a well-recognized annual problem on the Pacific coast and occurs occasionally along the Gulf of Mexico. Under environmental conditions of warm weather in summer months (March to November on the West Coast) and an influx of nutrients, the toxic dinoflagellates, Gonyaulax sp., undergo a population explosion or "bloom," resulting in the **"red tide."** The waters abound with patches of planktonic algae that turn the water into a variety of colors including red, yellow, brown, green, black, blue, or milky white.

Unlike many marine animals, mussels and clams ingest and sequester the poison without damage to themselves. Contrary to popular belief, there is no practical method of distinguishing contaminated (or poisonous) mussels and clams from edible ones. Usual cooking methods do not remove the toxin. In some areas, taking of certain clams and mussels is banned during critical months. Abalone, as well as crabs, do not feed on plankton nor are their viscera usually consumed; for both reasons, there is no danger of shellfish poisoning from them. Divers must be

especially cautious and consult with local authorities before collecting marine animals for human consumption. All plankton feeders may, at times, become poisonous.

When consumed by humans, the toxin acts directly on the central nervous system, affecting respiratory and vasomotor centers, and on the peripheral nervous system, producing complete depression. With large doses, respiration may cease instantaneously; with smaller doses, symptoms of nervous system involvement are slow and progressively worsen. Gastrointestinal symptoms (nausea, vomiting, etc.) are less common. Death in severe cases is almost invariably the result of respiratory paralysis and usually occurs within 12 hours. Medical attention should be sought immediately if unusual illness occurs after eating mussels or clams. For details of treatment, consult medical references [6,12].

Fish Poisoning

Ciguatera poisoning results from eating a wide variety of unrelated fish that contain ciguatoxin. Ciguatoxic fish feed on certain plants or bottom fish, implicating specific species of algae. It has been suggested that the proliferation of toxic algae may be triggered by contamination of the water by industrial waste, metallic compounds, ship wreckage, and other pollutants. As the feeding progression develops, the toxins appear to accumulate in the fish. Larger and older fish are more toxic [8]. More than 400 species have been implicated. Over 75% of the cases reported involve barracuda, snapper, jack, or grouper. Hawaiian carriers also involve the parrot-beaked bottom feeders.

Approximately 24 persons are hospitalized annually in southern Florida for ciguatera poisoning from barracuda. There is no seasonal variation, but larger specimens are believed more likely to be toxic.

The onset of symptoms is generally within 15 to 30 minutes of ingestion, with an increase in severity over the following 4 to 6 hours. Rarely, the onset may be delayed for up to 24 hours. Many (about 40-70%) victims have a sudden onset of abdominal pain followed by nausea and vomiting, a watery diarrhea, and a metallic taste in the mouth. There is a wide spectrum of other symptoms, from numbness of the lips, tongue, and throat to fever and chilling sensations. If poisoning is untreated, death from respiratory failure may occur. Divers must be cautious about fish they eat. Unusual illness following consumption of fish, especially barracuda, should receive immediate medical attention. The attending physician should be informed that fish has been consumed within the last 30 hours.

Tetrodotoxin poison is one of the most potent poisons found in nature and is characteristic of pufferfish, porcupine fish and sun fish. The toxin is distributed throughout the entire fish

with the greatest concentrations in the liver, gonads, intestine, and skin. In Japan, eating **fugu** has been a gastronomic version of Russian roulette for centries. The meat has no fiber; it is almost like gelatin -- light in taste, like chicken -- a gourmet's delight. The consumer is said to experience extraordinary neurological sensations. In a 10-year period the toxin claimed nearly 200 lives in Japan with about 60% of the puffer poisionings proving to be fatal. Yet fugu is the epitome of gourmet dining in Japan [31].

The onset of symptoms is as rapid as 10 minutes or can be delayed up to 4 hours. Initially, the victim develops oral tingling (paresthesia), which rapidly progresses to light-headedness and generalized tingling sensation. These sensations are rapidly followed by nausea, vomiting, and paralysis. Monitor victims continuously and acquire immediate medical attention. Resuscitation procedures may be required shortly after the onset of symptoms [6]. Most western authorities feel that it is best to avoid consumption of all puffers, even when prepared by experts. Keep in mind that toxic puffers are found in the Indian Ocean, South Pacific, Hawaiian waters, Sea of Cortez, tropical Western Atlantic (including Florida, Bahamian, and Caribbean waters) and in other waters throughout the world. A few non-toxic northern puffers are used as food fish [31].

Scombroid poisoning is possible from fish tissue that has been exposed to the sun or left to stand at room temperature for extended periods. Within a few minutes of eating the toxic fish, which has a peppery or sharp taste, the victims develop nausea and vomiting. Various other symptoms, such as intense headache, massive red welt development, and intensive itching, follow. Immediate medical attention is needed.

FRESHWATER LIFE HAZARDS

Compared to the oceans, freshwater streams, ponds, and lakes have relatively few forms of animal life that present a specific danger to divers. The diver must, however, be aware of those few species that can inflict considerable harm. Shelby and Devine were among the first to emphasize aquatic hazards to the diving community [27].

Reptiles

The venomous **cottonmouth** water snake, Agkistrodon piscivorus, is found in lakes and rivers south of latitude 38 degrees north. This snake is probably the diver's most serious aquatic hazard. It predominantly inhabits stagnant or sluggish water but has been observed in clear and moving water.

There has been a persistent notion that the cottonmouth would not bite underwater; however, Shelby and Devine documented two fatalities caused by cottonmouth bites [27]. The cottonmouth

is considered pugnacious, adamant, and vindictive when disturbed and will attack unprovoked. It does not show fear toward the human as most other aquatic snakes do; its behavior is unpredictable. Attack is more likely to occur in the evening.

Recognition is difficult since its color varies from jet black to green with markings absent or vaguely similar to the **copperhead** (Agkistrodon contortrix). Consequently, in areas where the cottonmouth is known to exist, it is advisable for the diver to regard any snake that does not swim away when encountered as a cottonmouth. The best defense is a noiseless, deliberate retreat. Wet suits afford reasonably good protection but can be penetrated by larger specimens. Bare hands should be tucked under the armpits. The diver should never attempt to fight since this will probably only result in multiple bites. Although evidence is inconclusive, it appears that the snake will not dive deeper than about 6 feet.

The **timber rattlesnake** (Crotalus horridus) is an excellent swimmer on the surface. Skin divers should be alert and avoid contact.

First aid for venomous snake bites includes:

* Keep the victim quiet and take measures to combat shock.

  Immobilize the bitten extremity and keep it at or below heart level.

  NOTE: If the victim can be hospitalized within 4 to 5 hours and no other symptoms develop, no further first aid measures need be applied.

* If mild to moderate symptoms develop and the bite is on an extremity, immediately apply a constricting band about 2 to 4 inches above the bite. Periodically check the pulse in the area beyond the band to insure that the flow of blood has not stopped. Loosen the band, if necessary, but do not remove.

* If severe symptoms develop, apply skin antiseptic over and around the bite and incise (about 1/2 inch long and not too deep; cut along the long axis of the limb) with a sharp blade.

* Apply suction with devices available with snakebite kits if available.

* Acquire immediate medical attention. Antivenin treatment may be required.

Consult American Red Cross first aid manuals for further informaton [1].

Turtles

Three species of aquatic turtles may be hazards to the diver if provoked and mishandled, especially large specimens. Though not venomous, they may inflict a serious, dirty wound. The **alligator snapping turtle** (Macrochelys ternminchi) found through the watershed of the Mississippi River, is vicious and aggressive when provoked. It has powerful jaws and sharp claws. The alligator snapper is recognized by three, distinct, keel-like lines running longitudinally the full length of the upper shell. There are also wart-like projections about the head and forelimbs. The alligator snapper is extremely long and muscular and can strike rapidly by extending the neck.

The **common snapper** (Chelydra serpentina) is smaller and similar in appearance to the alligator snapper. This species is considered by some authorities to be more vicious when provoked than the alligator snapper.

The **softshell turtle** may also inflict a serious wound. Contact with these turtles should be avoided or special precautions taken in handling.

Standard first aid for laceration wounds is recommended [1]. Tetanus immunization is recommended.

Alligators and Crocodiles

The **American alligator** has been encountered by divers but is not known to be aggressive or to cause injury. Yet the potential of injury is present, and divers should be cautious. In Central and South America, the **crocodile** may certainly constitute a hazard to divers, and in Africa the crocodile is responsible for many human deaths each year. The **saltwater crocodile** of the coast of Queensland, Australia, is very large (up to 30 feet) and reported to be a vicious aggressor.

Mammals

The **common muskrat** is the only warm-blooded animal that would probably attack a diver in U.S. fresh waters. It attacks only in defense, and the wound is usually minor. However, the possibility of rabies is present and serious. It is important for the diver to seek medical advice if bitten and for the animal to be captured or killed for laboratory examination. If encountered while diving, the muskrat should not be provoked. If it is provoked into attack, escape is virtually impossible.

Fishes

The only freshwater fishes of noted hazard to divers are the **freshwater sharks** of Lake Nicaragua in Central America and the **piranha** fish of the Orient and South America. In U.S. waters the only fish capable of inflicting serious injury are those of the catfish family, which are discussed in the section on venomous marine fish, and the **gar.** The gar fish commonly weighs in excess of 100 pounds and, if provoked by spearfishermen, has the capability of inflicting wounds with needle-sharp teeth.

The previous discussion has concentrated on the freshwater life hazards of the United States. Certainly, it is only common sense for the diver to consult with local authorities prior to commencing diving in other parts of the world.

MARINE AND FRESHWATER PLANTS

Kelps, the great brown algae of northern waters, is considered a potential hazard for divers. West Coast kelps, the bladder kelp, are large, and some grow to lengths of over 100 feet. A tough holdfast anchors the kelp to the rocky bottom and air bladders float the plant to the surface, where it spreads out to form a thick, floating canopy. The diver, in moving about underwater, may find himself under such a canopy. If he must surface under the kelp, the diver should select the least dense area of growth and extend his hands overhead to part the kelp and make an opening for his head. He can then visually determine the shortest and safest route to open water, submerge (feet first), and swim under the kelp canopy. The surfacing process can be repeated if necessary. Attempting to swim "through" the kelp on the surface usually results in severe entanglement. When swimming in or around kelp, the diver should frequently check projecting equipment to keep free of entanglement. Ribbon kelp is similar to bladder kelp, but tougher.

Surf grass or **eel grass** grows in the surf zone. Though possible, entanglement is not common. The surge may wash it over a diver, causing panic. However, when the surge reverses, the grass will move away and the diver may surface.

A number of **freshwater plants** are found in dense growth in some inland lakes. Divers can become entangled in the plants, and surfacing may be difficult. Panic is the diver's worst foe in a plant entanglement situation. In one recent incident, a Michigan diver became entangled in a weed-covered bottom and surfaced in a panicked state. He was treated for an air embolism at The University of Michigan. An entangled diver should stop, relax, and systematically untangle himself. Naturally, the buddy will be of considerable aid.

DIVING IN POLLUTED WATERS

Man has polluted his environment. As the contamination of our rivers, lakes, and oceans continues, one certainly must question the quality of the water that thousands of divers from the U.S. and Canada enter each year. Aside from the inorganic pollutants such as mercury, lead, beryllium, antimony, and cadmium, there is a more serious threat. Bacteriological pollution is a fact. Many microscopic bacteria, such as typhoid bacillus, can be easily detected by health authorities. However, many protozoans are not as easily detected.

Lamirande reports the death of a diver in Florida from a rarely diagnosed, incurable disease of the central nervous system caused by the amoeba Naegleria gruberi [22]. This amoeba has been found in lakes of Florida, Texas, and Virginia, as well as several foreign countries. Several deaths due to this amoeba have been recorded in the United States in recent years. The amoeba may lie dormant for many years until nutrient levels in the body of water are concentrated enough to stimulate uncontrolled development. Naegleria gruberi may enter the body through the nose, bore into a nasal nerve, and migrate to the brain, where they multiply by the thousands. The result is slow, agonizing death.

Though fatalities of this sort appear to be uncommon today, we cannot predict what will happen tomorrow. Toxic pollutants including organic mercurials, hydrocarbons, and some heavy metals can prove harmful to the underwater swimmer. Toxic chemical spills, solvents, herbicides, sewage, and petroleum by-products can constitute unacceptable risk for divers. Divers must use considerable discretion regarding dives in obviously polluted waters. Being aware of this hazard isn't really enough. The only true defense is to take appropriate actions to eliminate pollution or accept the fact that acceptable waters for diving (and drinking) may progressively disappear.

CONCLUSIONS

Prevention of injuries is the best policy. Through proper diving techniques, buoyancy control, environment familiarity, and common sense precaution most diving injuries can be prevented. Carelessness and improper diving techniques lead to injury. Do not handle marine organisms that you are unfamiliar with and do not take chances with those which you know can inflict injury.

Most divers are unprepared to administer proper first aid. Generally, they simply lack the proper "tools." A review of the procedures given in this paper indicates that a properly equipped tropical diver should include the following items in a personal or group kit:

1. Large bottle of vinegar and/or alcohol (at least one pint);
2. Antibacterial soap;
3. Tweezers/needles/surgical blade;
4. Constricting band;
5. Sterile dressings and band aids (ample supply of assorted sizes);
6. Metal first aid kit container (with a water-tight cover) that can be used for heating water and large enough to allow immersion of an injured hand or foot (materials for heated water or chemically activated hot pack applications may be included in smaller containers);
7. Canned heat and waterproof matches for heating water;
8. Aspirin;
9. Adhesive tape;
10. Tourniquet;
11. Anesthetic and/or antihistamine cream; and
12. Snake bite kit suction device.

All divers are encouraged to complete a basic/advanced first aid course. Whenever diving in an unfamiliar area, the diver must consult with local divers, professional lifeguards, diving instructors or other knowledgeable authorities regarding potentially hazardous marine life and first aid for specific marine life injuries.

There is still much to be learned regarding first aid for marine life injuries. Changing trends in modern basic first aid practices raise questions regarding "acceptable" procedures for managing a marine life injury.

Some diving instructors in the United States are quick to condemn the first aid procedures specified by Australian authorities. However, North American divers do not live daily with the potential serious consequences of injuries inflicted by such animals as the sea wasp, the blue-ringed octopus, and sea

snakes. We must acknowledge the opinions of those persons who deal with these animals on a routine basis. Diving instructors and divers must remain abreast of new developments in first aid. Efforts must be made to establish universally accepted procedures. In the meantime, United States divers must know what first aid practices to expect when working with divers from foreign countries.

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